Steel Quality Role of Secondary Refining and Continuous Casting
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Module - 03
Lecture - 16
Cleanliness Measures in Mould

In the last session I have started covering the cleanliness measures required during continuous casting, before that I had talked about during secondary refining how cleanliness measures can help in achieving the desirable quality parameters.

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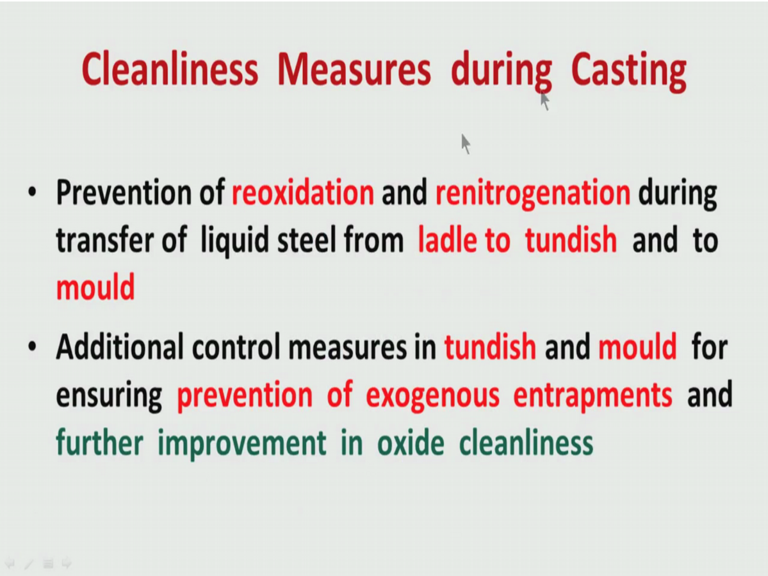

So, during continuous casting as I have told there are two basic issues; first the reoxidation and renitrogeneration has to be prevented because you know liquid steel is getting transferred from the ladle to the tundish and from tundish to the mold. So, during this process liquid steel should not be allowed to fall freely; that means, it has to be covered. So, that there is no reoxidation or renitrogeneration that is the first requirement.

Next is there has to be some additional control measures like what I have talked about in you know secondary refining. So, here also during continuous casting, there has to be some control measures in tundish as well as in mold cleanliness casting mold for ensuring prevention of exogenous entrapments. The whole idea is we have taken lot of care for producing a good quality steel of the secondary refines. So, all our efforts should not go to waste; whatever good cleanliness level we have achieved we have to maintain it there should not be deterioration, additionally we have to see to what extent we can prevent additional exogenous entrapments for further improvement in oxide cleanliness.

One is whatever improvement has taken place there should be no deterioration, there has to be no reoxidation no renitrogenation moreover there has to be prevention of exogenous entrapments in additional exogenous entrapment should not get you know entrapped or entrained in steel liquid steel so that the oxide cleanliness does not deteriorate.

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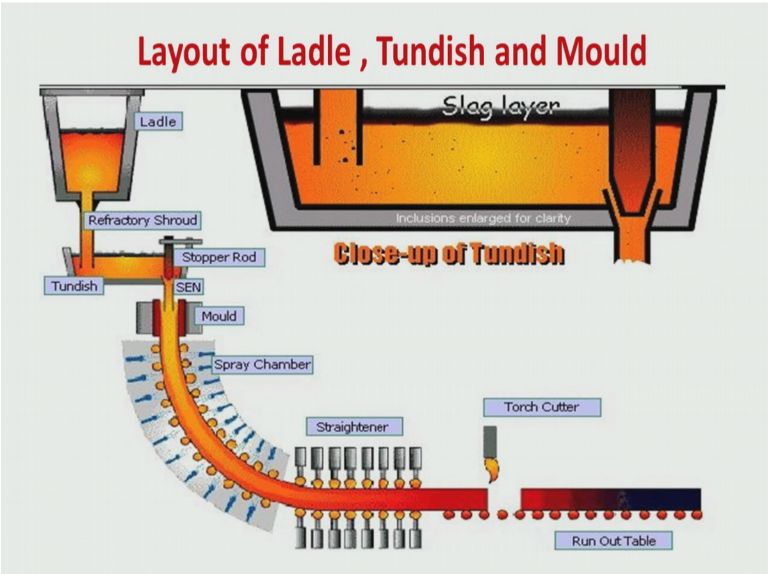

So, we have to be careful about those. I have told you this is a layout this is the ladle then there is a tundish and then there is a mold continuous casting mode. So, we have to be careful about some care we you take in the ladle itself, because when the liquid steel is coming from ladle to tundish we have to be careful, then we have to be careful in the tundish itself because the liquid steel stays here for quite some time, because ladle you know maybe 150 ton or 200 ton one ladle can contain maybe 250 ton maximum 300 ton, but when the ladle is emptied the liquid steel comes down in the tundish ladle is emptied, this ladle will go another ladle will come here.

But the tundish will remain that is what the continuous casting is, there will be several ladles one after ladle after another ladle will come liquid steel will get poured in the tundish. So, tundish is very important as a buffer between the ladle and the continuous casting mold unlike ingot casting, but the ladle liquid steel is from the ladle liquid steel is pouring directly in to the mold, but that is only for one heat, but here continuous casting means several heats can be cast one after another without any interaction for that we required tundish which is known as the buffer vessel. So, tundish also is very important as for as quality is important we have to be careful.

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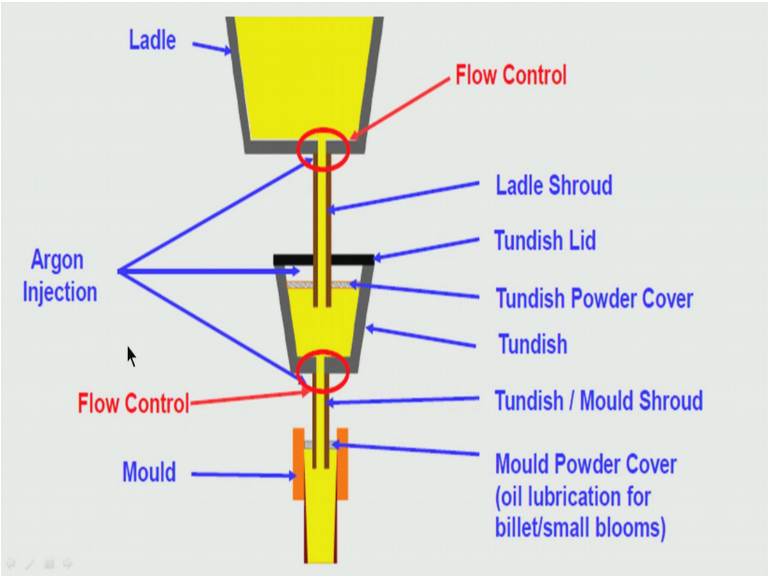

So, today I will talk of that how you know important tundish is; then I talked about from ladle when liquid steel is coming to the tundish there at the exit of ladle there is a flow control device.

So when liquid steel is allowed to come through this flow control device argon injection is necessary I had mentioned. So, there has to be a ladle shroud as a refractory shroud as well as there is argon injection to control deoxidation reoxidation; that means, no oxygen pick up should be there no nitrogen pick up should be there; that means, the air ingress has to be stopped to whatever extent it is possible it has to be controlled. Similarly from tundish to mold when liquid steel is coming down there is a you know refractory shroud we call this sub entry nozzle and also argon injection has to be there here because liquid as I was telling liquid steel should not be allowed to. So, you know come a come down on its own in air there has to be a cover refractory cover as well as iron cover argon cover sorry so that there is no contact with air. So, these are very important requirements.

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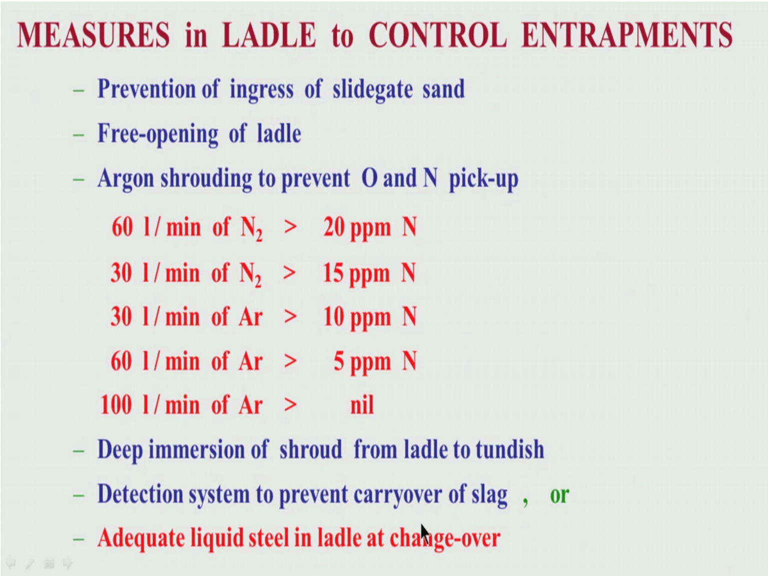

Then I have talked about in ladle what can be done I have mentioned that you know at the bottom of the ladle you know when you are pouring or when you are doing lot of secondary refining the ladle here the bottom is closed the exit has to be closed.

So, how it is done? It is done with the help of an slide gate sand because when you open the slide gate this sand also comes down. So, we have to be careful this sand is a source of exogenous entrapment again, this sand is necessary you know to close the exit of the ladle, but when you open the ladle; that means, when you aim for free opening of ladle; that means, when you remove the slide open the slide gate liquid steel should come out without any problem. So, for that the sand also should come out, but the sand should not be allowed to fall in the tundish, you have to take something we have to take measure to remove to take the sand so that it does not fall in to the tundish; that is one prevention of ingress of slide gate sand in the tundish that is one. Next I have told free opening of ladle ladle should open free; that means, when you open the slide gate there should be opening of the ladle; that means, the liquid shield liquid steel should come down from the slide gate exit.

So, this is called free opening, there should not be you know any iron sorry what is that called any oxygen poking you know sometimes it is required when the ladle is not opening free you have to use a oxygen lance to open it. So, in that process what happens the liquid steel gets oxidized. So, that is not desirable. So, it should open free and for that only we are using slide gate, the proper quality of sand is very important here for getting free opening.

So, when you are opening it free then what happens? As I was telling you we have to use argon shrouding; now the question is how much argon do we use I had mentioned in the last session that we have to use around 100 liter per minute of argon to control total you know cut off of air ingress. If you less amount of argon say 30 liter per minute then maybe 10 ppm of nitrogen pick up and also there will be oxygen pick up nitrogen pick up means also there will be oxygen pick up because both of these are coming from air. So, 100 liter per minute of argon is necessary to control to reduce this pick up of nitrogen and oxygen.

Another important requirement is a deep immersion of shroud from ladle to tundish this helps again to control the pickup of oxygen and nitrogen from air, it has to be immersed quite deep in to the tundish in liquid steel then there has to be a detection system to prevent carryover of slag. As I was telling yesterday when you know liquid steel is coming down from the exit from the exit of the ladle, towards the end of the ladle slag tries to come in because slag is there at the top of the liquid steel. So, when you are trying to empty the ladle of liquid steel if you are not careful some amount of slag might come. So, we have to be careful that this slag should not be allow the flow gate either the flow gate or the slide gate should be immediately closed.

So, how do you do that? For that there has to be a detection system to carry over to prevent carryover of slag when you do not have this detection system then what do you do you allow some amount of liquid steel in ladle at change over. So, there will be some loss of liquid steel because it is a good liquid steel, we have done a lot of secondary refining you know attempts to make the liquid steel clean. So, we want the whole amount of liquid steel should come in to the tundish, but we do not want slag to come in to the tundish. So, prevent the slag there has to be a detection system, if there is no detection system then you keep some amount of liquid steel in the ladle at change over so that no slag finally, comes to the tundish.

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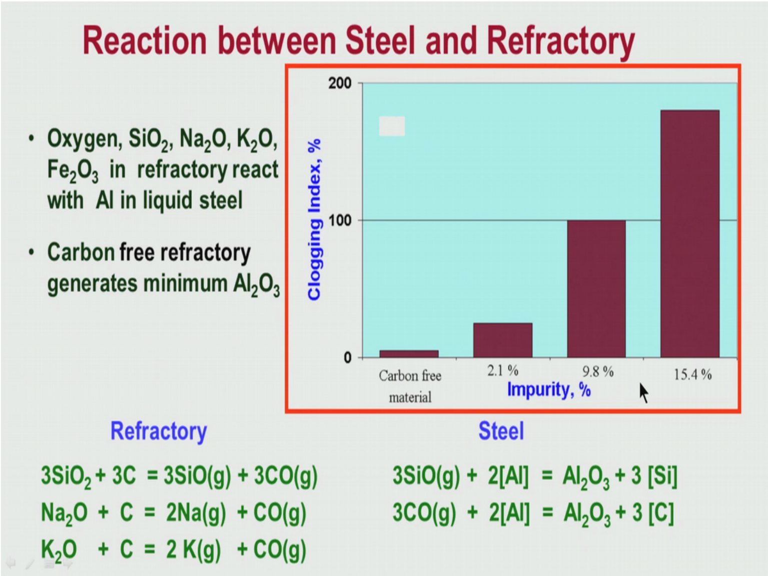

Then I talked about the importance of refractory what are the constituents is refractory which can cause reoxidation in liquid steel. I had mentioned that the refractory should not have source of oxygen; that means, Sio 2 sodium oxide, potassium oxide, iron oxide the carbon also in the refractory as an impurity should be as low as possible.

Why because you know if I if you have Sio 2 it will react with carbon of the refractory and will generate Sio and CO these are gaseous constituents, then this Sio will react with aluminum dissolved aluminum in liquid steel because you have killed the liquid steel with aluminum. So, some amount of liquid some amount of elemental aluminum will remain in liquid steel always. So, this aluminum in liquid steel will react with Sio will react with carbon monoxide and will generate alumina. So, again we have to remove this alumina then which is not desirable. So, this alumina should not you know too much of alumina should not get generated in liquid steel, because then this alumina again has to be removed from liquid steel as I had told you earlier.

So, the refractory material should be as much free as possible from Sio 2, sodium oxide, potassium oxide, iron oxide and carbon. So, I have shown here if you have high amount of impurity in the refractory the incidence of clogging; that means, incidence of jamming of you know the orifice the refractory orifice will increase. So, we have to be very careful the if you if the carbon free material we use we use almost nil amount of Sio 2 sodium oxide, potassium oxide, iron oxide, you are using mainly magnesia why you know refractory in absence of all these element clogging index is very low, and it is a good refractory and there will be not much of generation of alumina which is the source of again you know problem for cleanliness. So, this is again another important issue which have to remember.

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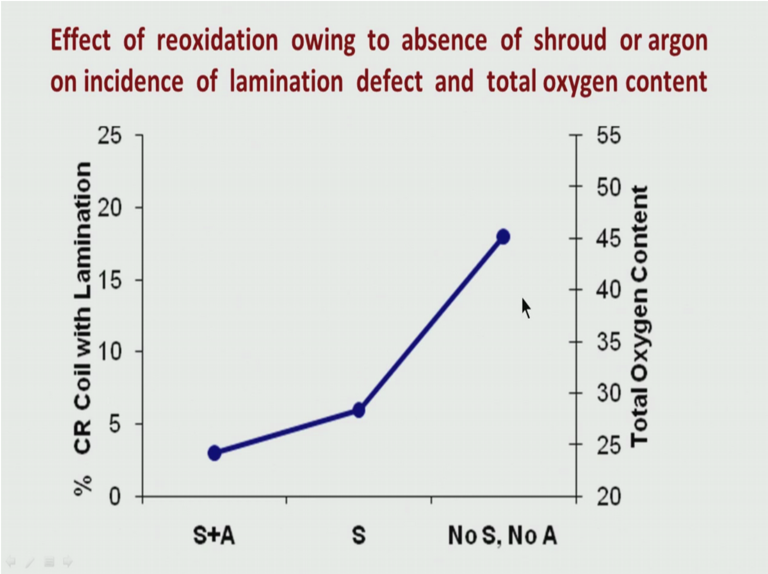

Then let me show you what happens if you are not using shroud; either refractory shroud or you know argon shrouding. This we have measured we have done lot of experimentation with this for a continuous caster. If we do not use shroud or argon then what is the level of total oxygen content total oxygen content I have told you is basically measure of because the dissolve oxygen is very small may be less than 5 ppm when you use an aluminum killing, but there is you know some oxides in liquid steel which is a measure of total oxygen content. Total oxygen means dissolve plus oxygen as oxide. So, if the dissolve oxygen content is less than 5 ppm. So, if you have 45 ppm of total oxygen content; that means, around 40 ppm of oxygen is present as oxide inclusions in steel which is not desirable. So, where from it has come because we have not use shroud we have not used you know argon. So, lot of oxide inclusions have formed alumina oxides are formed.

So, this will create lot of cleanliness problems. If you use shroud just refractive shroud this comes down from 45 ppm to to around say 30 ppm is slightly less than 30 ppm just imagine what is the effect of shroud; what is shroud doing it is allow not allowing the liquid steel to get in touch with normal air from which oxygen pick up and nitrogen pick up will be there. On top of that if you use argon shrouding; that means, refractory shroud plus argon as I have told you earlier. So, then your total oxygen can come down to 25 ppm. So, just imagine if you do not use this refractive shroud or argon we have very high amount of total oxygen; that means, high amount of oxide.

So, it is the problem for oxide cleanliness it is not desirable. So, we must use refractory shroud we must use argon cover argon you know shrouding to get good amount of cleanliness. Now this side I have shown if we have higher amount of total oxygen the final CR means cold rolled coil, whatever final product we are producing will have lamination type of defect which is getting generated from the alumina inclusions. If you have high amount of alumina inclusions more and more laminations is the defect will be generated on the surface of the cold rolled coil.

So, the percentage of such defect comes down when you control the total oxygen content in steel. So, from the cleanliness point of view from good quality point of view we must use refractory shroud and argon to have a good quality of the product.

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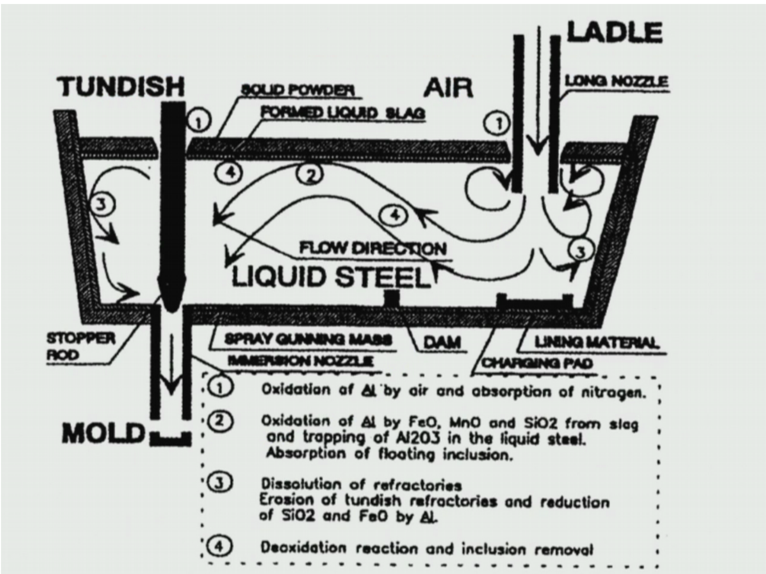

Yesterday in the last session I had just started talking about what is tundish what happens in tundish, what are the issues how we have to be careful during casting so that there is no exogenous entrapment from the tundish. So, this is liquid steel coming from the ladle. So, there is a I was talking about the refractory nozzle this is that refracting nozzle shroud refractive shroud, and we must use some argon also here so that there is no air ingress here now this is the total tundish.

So, this from liquid from ladle liquid steel is coming here, we do not want liquid steel to straight away go to the exit of the tundish why we want liquid steel to remains for some time in the tundish what we call is a residence time. Residence time of liquid steel in the tundish should be high so that whatever inclusions or exogenous in you know entrapments try to ingress in liquid steel will get adequate time to float up. So, for that we can use some flow control devices like dam and weir in the tundish, this will allow the liquid steel to take a circuitous route, it will not straight away come from here and going to the exit of the tundish.

So, it allows the liquid steel to remain in tundish for some time. So, this is called increasing the residence time of liquid steel in the tundish. So, the flow control device have some role dams and weirs. Moreover I had mentioned the liquid steel should not be allowed to impinge directly at the bottom of the tundish there might be damage for the lining of the tundish. So, there is a charging pad at the bottom of the tundish just beneath the entry of the liquid steel entry. So, it is protects the tundish bottom at this location from direct impact direct impingement of liquid steel.

So, this is again important otherwise you know there will be erosion of liquid steel erosions sorry liquid erosion of the lining material of the tundish. Now just look at what is happening one basically means there is a possibility of reoxidation because of air ingress we have to be careful then again when liquid steel is going and getting in contact with the slag this one is the slag, at the top of the liquid steel there is slag I will I have discussed what is the constituent of slag here. So, there have there may be a possibility of oxidation of aluminum in liquid steel by air and absorption by oxygen again if there is air ingress.

So, we have to be careful there should be no air ingress then at the slag liquid steel interface there is a possibility of again reoxidation of aluminum, if you have constituents like if you iron oxide manganese oxide, silicon oxide in the slag like I have mentioned in the ladle slag should be basic and there should be less amount of your know iron oxide, manganese oxide, oxides like those Si silicon oxide. So, that there is no reoxidation here also there should be less amount of reoxidation.

So, the slag normally two layer of slag is used in tundish, the slag liquid slag which is just above the liquid steel must have more amount of c o the basicity should be high. Sio 2 F e o m n o should be very small so that you know reoxidation is less whatever alumina is there in the liquid steel should get absorbed. So, for that more amount of c a o is necessary, but at the top of that you know insulation is also necessary, so that liquid steel temperature should not come down during the process of casting.

So, this is a two stage you know slag is use. Slag the bottom slag which is just at the top of the liquid steel is basically a basic slag on top of that we use rice husk which is a good insulation material, this does not allow the liquid steel temperature to come down. So, we have a two stage slag one just at the top of the liquid steel we have a basic slag, which is use for absorbing the alumina oxides which are you know forming and trying to get up and come to the top, and on top of the basic slag we have a another constituent of slag which is known as rice husk. Basically it allows the is a good insulator it allows the liquid steel temperature to not to fall the uncertain limits now this at this point there is a possibility of you know erosion of the refractive this is the refractory lining at this locations.

So, dissolution of refractories; that means, erosion of refractories should not take place. Erosion or tundish refractories and reduction of Sio 2 and F e o by aluminum these are the possibilities are there if the refractory lining is not basic. As I have mentioned in the ladle the same thing is true for here also refractory lining should not have Sio 2, should not have you know iron oxide, should not have other constituents which might get reduced with by aluminum then at this point as I was discussing.

So, some amount of deoxidation is possible in the refractory in the tundish, because you have small amount of aluminum here. So, whatever oxygen is there dissolved oxygen there is a possibility of deoxidation. So, alumina deoxidant whatever is forming is trying to float and should get absorbed. So, deoxidation reaction and inclusion removal; that means, removal of deoxidant alumina is possible in the tundish if you allow higher residence time if you allow the liquid steel to remain in tundish for some more time with the use of dam and weir.

So, the flow control devices are very important here. So, these are the actions which are necessary in tundish.

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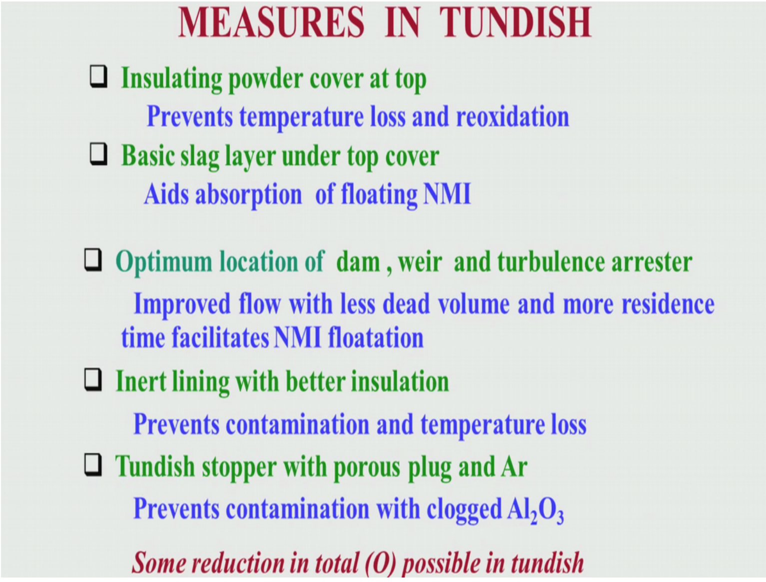

Now, I will indicate one by one what are the issues whatever I have told I will just indicate them one by one insulating powder cover at top I have mentioned rice husk type of material is use, prevents temperature loss and reoxidation prevention this is the purpose then basic slag layer under the top cover. This basic slag layer it is absorption of floating NMI alumina you know such type of entrapments. So, basic slag has to be there. So, on top of the liquid steel as a basic slag, on top of that there is insulating powder like rice husk, but there should be less amount of carbon in the rice husk because rice husk should be burn. So, that carbon goes out otherwise you know there is possibilities of carbon pick up so we have to be careful about that.

Now I have mentioned about the dam and weir and the turbulence arrester. So, all these flow control devices where do you put them. So, here is a question of doing some you know mathematical modeling of the tundish, a lot of people have done mathematical modeling to determine the location of dam weir and the turbulence arrester so that you have more residence time of liquid steel in the tundish, we have less turbulence in the tundish, you have less amount of dead zone in the tundish. So, for this optimum location of dam weir and turbulence arresters are necessary.

Then as I was mentioning we must have a good insulation it should not cause contamination you know or temperature loss this is very important. Then the tundish stopper with porous plug and argon this is very important because this is prevents contamination with clogged alumina. So, as I was telling you yes I like here is the flow control device from tundish and liquid steel is allowed to come in the mold. So, here you must use argon to prevent reoxidation and renitrogenation renitrogenation. So, there is a refractory nozzle we call it sub entry nozzle which comes from the tundish bottom to the mold.

So, there must be some flow control device to control the liquid flow whenever it is required it can be stopped whenever required it can be open to what extent it is open the way as to wave flow control. Along with the flow control in the refractory nozzle we must have argon injection. I have mentioned about this why it is necessary from ladle to tundish similar way it is necessary from then when the liquid steel is coming down from tundish to mold converse custom mold.

So, as I was mentioning the tundish stopper with porous plug should have provision for argon flow this is very important. Otherwise you know they will get possibility of clogging of with alumina because there is we have killed the steel with aluminum for good killing for good deoxidation. So, there will be some small amount of aluminum in liquid steel elemental aluminum in liquid steel which if it gets in contact with air will form alumina and is the possibility of clogging we must not allow that. So, argon shrouding argon covered is very much important. So, what I am mentioning here is like ladle we are doing lot of efforts to bring down the total oxygen level, in tundish also some reduction in total oxygen is possible.

Total oxygen is possible means oxide inclusions whatever are forming whatever contamination possibilities are there, if we allow them to stay in the tundish for some time those inclusions will float up and get absorbed by the basic slag. So, some amount of total oxygen reduction or some amount of cleanliness improvement is also possible in tundish.

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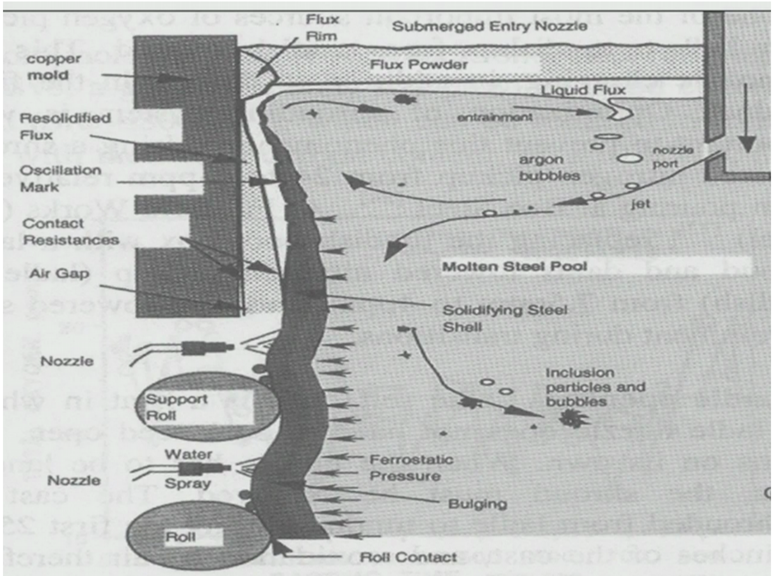

Now, after tundish when you are using continuous casting there is mold is a continuous casting mold; whether you are doing casting or bloom or billet or you know slag whatever it is there has to be a continuous casting mold the shape of the mold of course, is different depending on what you are casting, but there has to be a mold. No mold what is a mold? Mold is basically unlike ingot casting it is an open mold, you see this is the mold surface this is made of copper this is water cooled copper this is a copper mold. So, liquid steel is coming from the tundish through this nozzle which we are calling sub entry nozzle SEN. So, this is the poke nozzle poke through which liquid steel will come inside the mold. So, what is happening through this port liquid steel is coming also we are passing argon?

So, there is some argon bubble also is coming out in the liquid steel. So, this will go to take this path go to the surface, surface we have mold flux or mold we call it mold powder initially we use powder which will in contact with the liquid steel. So, some amount of liquid flux will form we call it mold flux. So, this is liquid flux which is forming from the flux powder. So, this is melting, there is some amount of liquid. So, there is some you know turbulence if there is too much of turbulence; that means, some amount of entrenchment of liquid flux is possible we do not want that because what is liquid flux is basically some oxides is a calcium oxide, alumina oxide, you know some amount of some amount of other oxides are also there. So, we do not want that some sodium oxide is there.

Some silicon is silicon oxide is there we do not want slag to get entrained here. So, again lot of modeling has been done just to just to ensure that there is not much of slag entrainment because of too much of turbulence with the liquid steel which is coming inside. So, this is very important. Now look at here this is that flux powder, this is the flux rim, and here you have a molten whatever molten liquid is there slag will come here will get inside, because that this is not stationary all of you are aware that the casting mode is not stationary it is getting movement like this there is a vertical movements top and down top and bottom top and bottom it is moving otherwise you know there is a possibility of sticking of the shell this is the solid shell which is forming in solidification it might get stuck to why it does not get stuck first that is liquid steel here sorry there is a molten slag here which is preventing the shell to get in touch with the copper mold and also there is a vertical movement of the copper mold.

So, this helps the liquid rather the solid shell not to get stuck with the mold surface this is very very important. So, what happens because of the shrinkage there is a possibility of formation of air gap here you know, because the shell liquid from the liquid steel whenever solid shell is forming you know solidification causes shrinkage volume is there is a volume change. So, there will be shrinkage. So, there is a shrinkage means it comes down comes away from the mold. The ferro static pressure of the liquid will try to push it towards the mold, but the shrinkage will try to take it away from the mold it depends which force is more. So, somehow some amount of shrinkage will also be there always

So, we have to be careful about this air gap too much of air gap formation means you know what is air gap this a insulation it will cut insulation. So, that liquid steel we should get cooled, how does it get cool it could get cooled by the copper mold, water is flowing inside the copper mold. So, this is chilled mold water cool mode. So, heat transfer is there from here heat is going out going out in this direction. So, if there is a air gap formation. So, there is a insulation. So, there is a heat transfer gets impeded heat transfer is less at this locations because of air gas formations they have to be careful about that. So, after the mold below the mold they are supporting roles and in between there is a water spray this is a primary cooling is done in the mold, but when the shell is coming out of the mold the shell thickness has to be sufficient all of you know otherwise there will be a breakout.

So, the strength of the shell when it is coming out of the mold because unlike you know ingot mold there is nothing at the bottom. So, that liquid steel is supported by the solid shell here thus the solid shell must have adequate strength otherwise they will be rupture of the solid shell and there will be break out and there is a there be a chaos the whole casting has to be interrupted you know the casting floor will be flooded with liquid steel there might be accident. So, we have to be very very careful about that. So, the shell thickness is very important.

So, after below the mold the cooling is done by water. So, this is called primary cooling inside, the mold below the mold it is called secondary cooling it is done by water or air mist there may be a mist means air and water combination there may be a mist cooling that may be water cooling it depends this cooling is better because it is more uniform more soft, which is always desirable, but there has to be additionally as to some support rows you know otherwise what is going to happen. This shell here the thickness is not much.

So, there is always a chance of this you know solid this ferro static pressure will try to push the shell because there is no support now inside the mold there were some support when you are coming out of the mold below the mold there has to be some support rolls which will act as a support to the thin solid shell. Solid shell is increasing in thickness at this you know height still there is not much of solid shell the thickness is not match. So, there has to be some support the support is given by the rolls moving rolls. There are two purposes of the rolls first is the support and that is it allows the shell to come down.

So, that is also another purpose because the rolls are moving this way, it is not stationary rolls though this gives a downward movement to the shell. So, there is air cooling and there is support rolls. So, in the mold also there is a possibility of contamination; contamination from where as I have told you contamination from the mold slag which is present here. If there is too much of turbulence you know there is a movement of the mold top and bottom top and bottom we call it, this movement is very much necessary otherwise there is as I have told you there is a possibility of sticking shell sticking. So, this mold also we call it mold oscillation it is oscillating it is going up going down is oscillating in a particular there is a frequency, how oscillation will take place there is an amplitude to what extent it will move up and down.

So, because of that or because of the turbulence the liquid steel level at the you know surface here should not move on move up or come down very much because the turbulence has to be controlled, otherwise the turbulence is much then there is a possibility of entrainment of the you know here liquid slag at this locations there is a possibility here it is shown. So, the turbulence in the liquid steel within mold is very important turbulence should not be much otherwise there is a possibility of contamination from the liquid you know slag, which is at the top of the liquid steel. So, there is a possibility of entrainment of liquid slag in the mold which is not desirable. So, we have to be careful in the mold as well.

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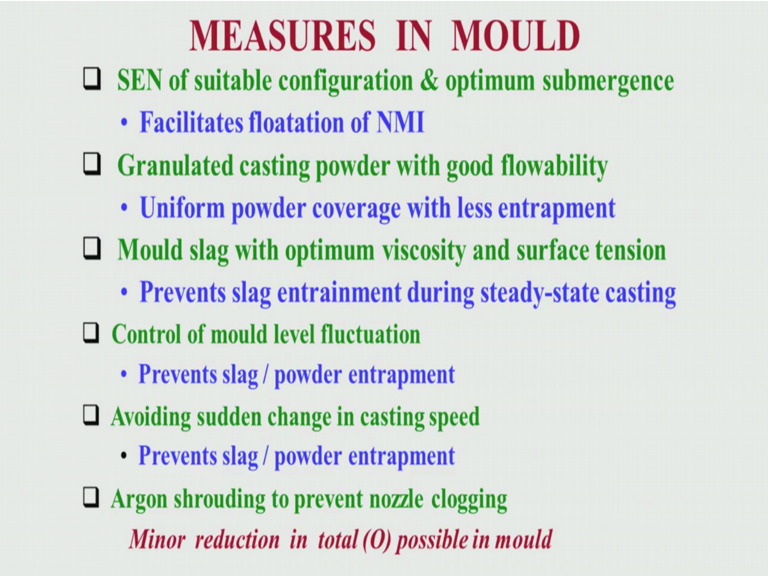

So, now let us see what are the issues in mold for getting good cleanliness? SEN is as I have told you sub entry nozzle, is must have suitable configuration and optimum submergence. Submergence is important like as I told in the tundish also that is submergence here also there is a submergence otherwise what is going to happen if it is not the submergence is not within if the SEN is not submerged in liquid steel there is a possibility of air ingress. So, that has to be some submergence moreover the liquid steel is coming out from this ports.

So, if there is not submergence that there will be too much of turbulence at the interface at that top of this called meniscus, at the meniscus there is a problem. So, the sub this is called sub entry nozzle it is submerged this entry nozzle is submerged. So, what should be the submergence again modeling can determine what should be the optimum level of submergence, what should be the you know orientation of these ports whether it will be horizontal, whether it will be at downwards, whether it will be at you know upwards all these have implications of the flow and turbulence of the liquid steel in the mold.

So, you know modeling plays a big role here in deciding what should be the configuration of the port exit port here. So, SEN of suitable configuration and optimum submergence this very important, this helps flotation of NMI whatever you know exogenous entrapments are getting generated suppose liquids you know slag mold slag is getting entrained in liquid steel we must give sufficient time for them to float up too much of turbulence is not you know desirable, but some amount of turbulence will help them to float up and get absorbed.

So, this is important; then granulated casting powder with grow up good for we have told you that powder is used for lubrication in the mold which will get molten and generate slag. But what should be the powder it should be granulated it is not just powder you know for good flow ability it is granulated casting powder it is not just normal powder granules are formed from the powder by melting if we get granules. So, have good flow ability this very important.

So, this gives uniform powder cover coverage; you can see that this is a flux powder it should be uniform you know because this also determines you know heat transfer to certain extent you know, if the powder coverage is not uniform on the top of the liquid slag somewhere it is less somewhere it is more than the heat transfer gas gets different from one point to another there is a difference in heat transfer which is not desirable. So, the powder characteristic is important.

So, granulated casting powder with good flowability is very important. So, to get uniform powder coverage with less entrapment we do not want entrapment this is the desirable requirement. Then this powder will generate the slag now this slag should have optimum viscosity and surface tension this again important why this is important first it should not get entrained. So, viscosity and surface tension because there is an interface between liquid steel and mold slag. So, the surface tension interfacial tension is important the viscosity is important so, that even if there is some turbulence this slag should not get entrained number one number two this slag for getting good lubrication should get inside this; that means, the slag should come down. So, viscosity plays an important role here, if the viscosity is too high slag will not come down it will not give the desirable lubrication and there will be a breakout.

So, there will be sticking between the shell and the you know mold surface and that is not desirable there will be a breakout. So, proper amount of viscosity is very important. So, this is given by the whatever the constituents are there, what are the constituents whether how much of CAO how much of alumina how much of sodium oxide will be there how much of barium oxide sometimes are added how much of calcium fluoride will be added, all these will give you what is the melting point of the you know powder which will create generate the slag what is the viscosity what is the surface tension. So, the constituents present in the powder will give us the desirable mold slag which has optimum viscosity and surface tension and melting point this is very important.

Slag entrainment should not be there and then control of mold level fluctuation this is very important. As I have told you because of many factors because of the turbulence there is a possibility of level fluctuation this meniscus level there is a possibility of fluctuation going up and down along with this along with the normal movement of the mold there is a possibility of fluctuation, there is a possibility of additional turbulence which is causes some amount of you know vertical movement of this surface which is not desirable because there is a possibility of entertainment of mold slag. So, for that there has to be a proper control on mold level fluctuation it can be done. So, it is normally done there mold level fluctuation.

So, it prevents slag or too much of fluctuation means even the powder which is present at the top of the slag that might get entrapped small amount of fluctuation turbulence will cause you know slag entrainment too much of fluctuation might cause even powder entrapment which is a very very undesirable. So, mode level fluctuation control is very important, then you know where from fluctuation takes place, too much of sudden change in casting speed suppose you are casting at a speed of say 0.8 meter per minute now suddenly the speed increases to say 1.1 meter per minute or suddenly it decreases there is a problem too much of fluctuation will take place that is called unsteady state of casting which is not desirable steady state means you are casting at a particular speed without much of fluctuation.

So, such non steady state is not desirable too much of change in casting speed is not desirable; then as I have told argon shrouding to prevent nozzle clogging is very very important if you do not use argon here there is a possibility of clogging of this ports as it happens for you know from ladle to tundish refractory nozzle poke here also there is a possibility of clogging, because there is some aluminum in steel. So, if there is a possibility of ingress of air, alumina will form this will cause clogging of this port if the clogging is too much maybe the casting has to be interrupted because no liquid steel will come out from the port. So, what happens the casting has to be aborted. So, clogging has to be controlled by whatever means available to us. So, we should I have mentioned here sudden change in casting speed is not good argon shrouding is desirable.

So, if you do all these measures some amount of cleanliness is additional cleanliness is also possible in mold, most of the cleanliness as I have told you we have taken care of in the ladle in secondary refining, some amount of cleanliness enhancement we have done in tundish, then say small amount of cleanliness and enhancement we can do in mold also if you take lot of care if we do not allow any entrainment of liquid slag, we do not use we rather we use argon of desirable to the desirable of desirable flow. So, that there is no air ingress we do not use too much of change in the casting speed too much of turbulence we do not want.

So, if we take all these measures then some amount of enhanced cleanliness is also possible in mold. So, our purpose is whatever good liquid steel we have produced in ladle after secondary refining that should be maintained and that should be enhanced like cleanliness level should be enhanced that should not get contaminated any amount of you know exogenous entrapment has to be restricted. So, in mold exogenous entrapment is the mold slag or the other mold powder this has to be controlled.